APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE

STRUCTURAL FABRIC AND METHOD FOR PRODUCTION THEREOF

BACKGROUND OF THE INVENTION

This invention relates to stitched or sewn non-woven fabrics and more particularly, it relates to fabrics made of stitched together tapes of fiber reinforced polymer (plastic) materials.

Fiber reinforced plastic structures have been used for many years with increasing success because of their high strength, light weight and ease of fabrication compared to wood or metal structures which they replace. Fibers such as glass, carbon and aramid are popular reinforcements, and thermosetting resins such as polyester, phenolic and epoxy are common polymeric matrices. Thermoplastic matrices are also used but their utility is compromised by their high viscosity which limits easy wet out of reinforcing fibers.

Polymeric materials reinforced with continuous or discontinuous filaments are used as precursors for highly stressed parts in aerospace and commercial components requiring the highest possible strength with the lowest possible weight. Highly viscous polymeric matrices such as thermoplastics have difficulty in impregnating a bundle of reinforcing fibers. The polymer can impregnate or flow between the fibers and bond to them if the fibers are spread apart, impregnated and then formed into a fiber reinforced plastic tape. These tapes can be then made into a fabric, which then can be molded under pressure and heat into a final part.

In the prior art Grimnes U.S. Patent No. 5,344,687 and U.S. Patent No. 5,569,344, layers of thermoplastic or thermoplastic fibers are interspersed between

the layer of reinforcing fibers and stitched together. When molded the thermoplastics flows between the structural fibers, the highly viscose thermoplastic does not tend to flow between the fibers very well and does not, when molded, make an end part of optimum strength.

In other prior art Binnersley U.S. Patent No. 4,816,327 and U.S. Patent No. 4,947,897 weaves together fiber reinforced polymer tapes. This allows a crimp to be formed by an over under pattern inherent in the weaving process which weakens the molded part.

The object of this invention, therefore, is to provide an improved structural fabric.

SUMMARY OF THE INVENTION

The invention is an elongated structural fabric including a first layer of substantially parallel fiber reinforced plastic warp tapes substantially aligned with the longitudinal axis of the fabric, a second layer of substantially parallel fiber reinforced plastic weft tapes lying transverse to the axis; and yarn looped around the warp tapes and the weft tapes so as to maintain the tapes in alignment. The fabric can be molded to produce a high strength, lightweight part.

According to one feature of the invention, the warp and weft tapes are positioned such that at least one of the first and second layers are substantially free of interstices. This feature enhances the strength of a molded part.

According to another feature of the invention, each of the first and second layers is substantially free of interstices. Molded part strength is further enhanced by this feature.

According to still another feature of the invention, the edges of the warp tapes in the first layer and edges of the weft tapes in the second layer are in substantial abutment. The abutting edges eliminate undesirable interstices in the layers.

In another embodiment of the invention, the warp tapes are in substantial abutment, and the weft tapes cross over themselves in a cross weft pattern.

According to other features of the invention, the warp and weft tapes are composed of a polymer reinforced with glass fibers. These materials optimize finished part strength.

According to yet another feature of the invention, the weft tapes are substantially perpendicular to the fabric axis. This feature facilitates manufacture of a desired fabric.

The invention also encompasses a method of forming an elongated structural fabric including the steps of positioning a plurality of warp tapes in a first layer with the warp tapes substantially aligned with the longitudinal axis of the fabric; locating a plurality of weft tapes in a second layer with the weft tapes lying transverse to the axis; and looping yarn around the warp and weft tapes to maintain the warp tapes in

substantial alignment with the axis and the weft tapes transverse to the axis. The method produces a fabric capable of being molded into high strength parts.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the invention will become more apparent upon a perusal of the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a schematic illustration of machinery used for forming a structural fabric;

Fig. 2 is a detailed view of an indexing mechanism in the machinery of Fig. 1;

Fig. 3 is a schematic view of warp and weft tape layers in one embodiment of the invention;

Fig. 4 is a schematic view of warp and weft tape layers in another embodiment of the invention;

Fig. 5 is a detailed view of a stitching mechanism in the machinery of Fig. 1; and

Fig. 6 is a schematic view of a stitched structural fabric of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fiber reinforced tapes of the general type disclosed in U.S. Patents Nos. 5,176,775 and 5,911,932 are loaded into creels 1, 2 shown in Fig. 1. Preferably, the tapes are polymer tapes reinforced with glass fibers. Warp tapes 3 are pulled from

the creel 1 and fed over rotating tension rollers 4 into a stitching head 10. Simultaneously, weft tapes 5 are pulled from the creel 2 and fed through a tension compensator 6 into a synchronized indexing carriage 15 mounted on a gantry 16. The indexing carriage 15 inserts the indexed weft tapes 5 into weft hooks 14 mounted on a continuous chain 7 (Fig. 2) which rotates clockwise and feeds the tapes 5 into the stitching head 10. A constant tension is maintained on the weft tapes 5.

As schematically illustrated in Fig. 3, the warp (0°) tapes 3 form a first tape layer 20 in the stitching head 10. The warp tapes 3 are indexed to lie parallel to each other and aligned with the longitudinal axis of the fabric formed in the stitching head 10 and moved therein in a direction 17. Conversely, the weft (90°) tapes 5 are indexed to lie parallel to each other in a direction 18 transversely perpendicular to the machine direction 17 forming a second tape layer 19 over the first layer 20 formed by the warp tapes 3. Although for clarity, the tapes 3, 5 are shown spaced apart in Fig. 3, in preferred embodiments the edges of tapes 3, 5 abut in, respectively, the first and second layers 20, 19 so as to substantially eliminate interstices in each of the layers.

Referring again to Fig. 1, polyester stitching yarn 24 retained on a cylindrical beam 8 is pulled through rotating tension rollers 9 into the stitching head 10. As depicted in Figs. 5 and 6 stitching needles 23 within the stitching head 10 loop the yarn 24 around the tapes 3, 5 securing them together forming an elongated structural fabric 12. Again, the tapes 3, 5 are shown spaced apart rather than abutting in

Figs. 5 and 6 for clarity. The finished structural fabric 12 then is fed through tension rollers 11 (Fig. 1) and over to a take up 13 where the fabric is rolled onto a cardboard core.

Schematically illustrated in Fig. 4 is another structural fabric embodiment 30 produced by the machinery of Fig. 1 in a manner similar to that described above. Again, warp (0°) tapes 22 are indexed into the stitching head 10 in a parallel side by side first layer arrangement running in the machine direction 17 and weft tapes 21 are indexed in a substantially parallel side by side second layer arrangement running transversely to the direction 17. However, in this embodiment, the weft tapes 21 cross over themselves (cross weft) and run substantially perpendicular to the direction 17.

Example

Continuous fiberglass reinforced polypropylene tapes were stitched together on a Mayer/Malimo P2 machine on 12/9/02. 7 tapes in the warp direction and 8.1 tapes in the weft direction. Two samples were made. One with parallel weft tapes and one with slightly cross weft tapes. The tapes (355 linear yards per pound) were composed by weight of 55% - 450 linear yards per pound fiberglass reinforcing rovings and a 45% polypropylene thermoplastic matrice. The fabric produced from the parallel weft tapes was 11.36 ounces per square yard in the warp direction, 13.14 ounces per square yard in the weft direction and .48 ounces per square yard for the polyester stitching yarn. The total weight of the fabric was 24.98 ounces per square

yard. The stitch was a #.087 tricot with a stitch length of 2.00 mm. The average thickness was .054 inches, moisture content .038%; loss of polymeric material upon ignition was 44.11%.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is to be understood, therefore, that the invention can be practiced otherwise than as specifically described.